



Aerospace, Chemical and Material Sciences

05 MAR 2012

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AFOSR/RSA

Air Force Research Laboratory

Integrity ★ Service ★ Excellence

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Aerospace, Chemistry and Material Sciences



The Directorate leads discovery and advancement of fundamental and integrated science that enables future air, space and cyberspace power.



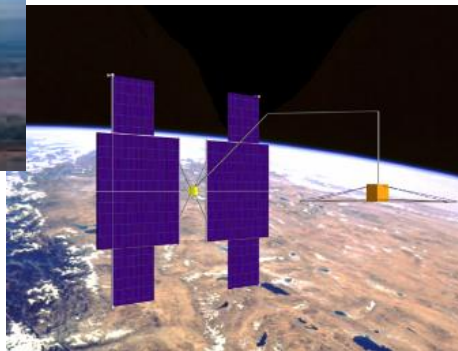
Fluid Mechanics



**Solid Mechanics
& Structures**



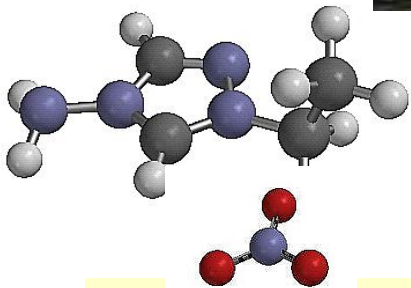
Propulsion



Materials



Chemistry



Transforming the Future of Aerospace Sciences

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RSA Investment Portfolio



Aerospace, Chemical & Material Sciences (RSA)

Aero-Structure Interactions and Control

- Flow Interactions and Control
- Aerothermodynamics and Turbulence
- Aerospace Materials for Extreme Environments
- Test and Evaluation

Complex Materials and Structures

- Organic Materials Chemistry
- Low Density Materials
- Mechanics of Multifunctional Materials
- Multi-scale Mechanics and prognosis

Energy, Power, and Propulsion

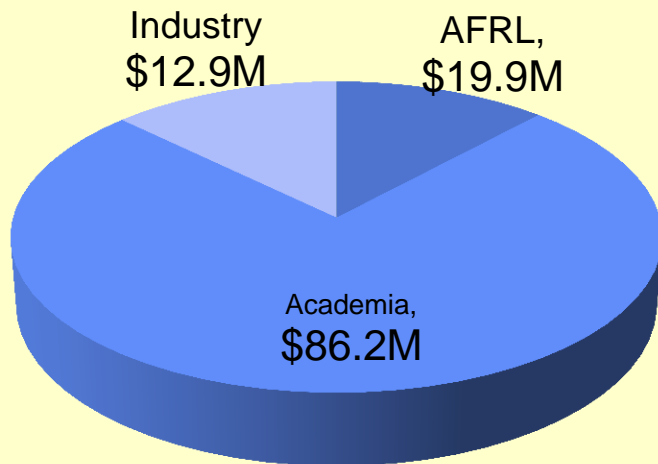
- Molecular Dynamics and Theoretical Chemistry
- Energy Conversion and Combustion Sciences
- Space Propulsion and Power
- Thermal Sciences

Programs: 12 Program Manager's Portfolios
Work Unit: >600 Individual Grants, Contracts





Aerospace, Chemical, and Material Sciences (BPAC 613002) Vision



(Total \$119.1M)

Aero-Structure Interactions and Control:

- Turbulence and laminar-turbulent transition
- Unsteady aerodynamics and flow control
- Aero-elasticity and structural dynamics
- Integrated Modeling

Energy, Power and Propulsion:

- Novel energetic materials
- Combustion and catalysis chemistry
- Thermal science
- Novel means of producing, collecting and storing energy
- System-level analysis and modeling

Complex Materials and Structures:

- Novel lightweight materials
- Materials with tunable properties
- Reconfigurable structures
- Multifunctional materials and structures

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Aero Structure Interactions and Control



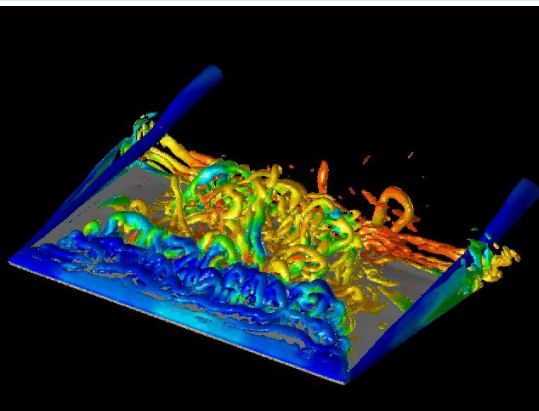
MOTIVATION

- Breakthroughs on the characterization, modeling and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Air Force systems.

STRATEGIC PARTNERSHIPS

- AFOSR, NASA, DOE, National Hypersonics Foundational Research Plan: Three NASA/AFOSR Basic Research Centers (Propulsion, Materials and Structures, Fluid Physics)

R. Gordnier, AFRL/RB High Fidelity Simulation of Highly Flexible Membrane Wings for Micro Air Vehicles



- Membrane Flexibility:
- ✓ Reduces the extent of leading edge separation
 - ✓ Enhances lift at the cost of increased L/D
 - ✓ Reduces nose down pitching moment

Effect of Membrane Flexibility on Leading Edge Separation

PAYOFF

- Increase smooth airflow over the vehicle's upper surface to reduce friction and heat
- Engineered maneuverable micro flight vehicles may incorporate of flexible wing membranes as lifting surfaces.
- Advance fluid physics knowledge base and resultant predictive tools



Energy, Power, and Propulsion

MOTIVATION

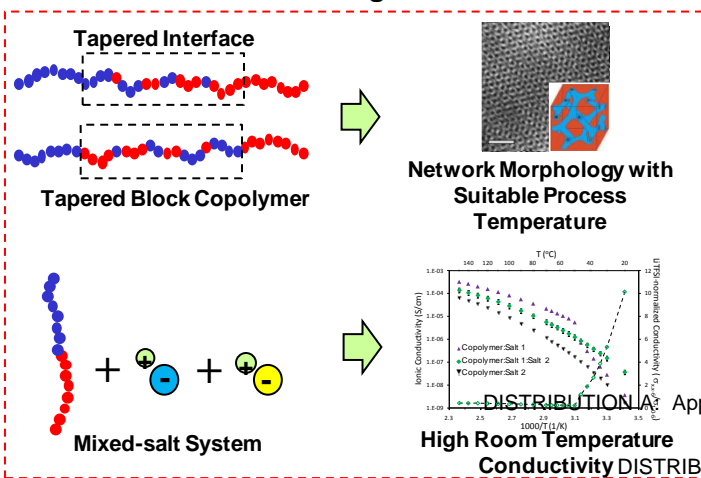
- Novel propulsion methods for aircraft and spacecraft are being explored, as are new ways in which energy can be produced, collected, stored, and utilized. Develop novel energetic materials, as well as understanding and optimizing combustion processes.

STRATEGIC PARTNERSHIPS

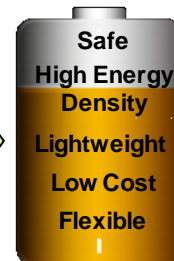
Interagency Combustion Working Group (MACCCR), joint coordination of the National Basic Research in Combustion (in particular for Alternate Fuels). Members are AFOSR, ARO, ONR, AFRL, SERDP, DOE, NSF, NIST, NASA, FAA

(PECASE)- Thomas Epps, U of Delaware

Ion-conducting Membranes



Future Lithium Batteries



PAYOFF

- Coated nanoscale aluminum powders could increase the performance by more than 25%
- These energetic ionic liquids have great advantages for use as monopropellants
- New hybrid multi-time scale algorithms to improve accuracy and time





Complex Materials and Structures



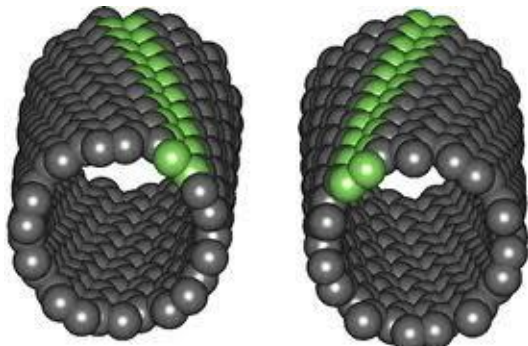
MOTIVATION

- Breakthroughs on future materials and structures that are composed of different classes of materials and may be able to change functionality and/or performance characteristics to enhance the mission versatility of future air and space systems.

STRATEGIC PARTNERSHIPS

NSF Collaborative project on Origami, ASDR&E COI Materials, Joint AFOSR/RX/RH Center of Excellence at Georgia Tech on Bio Materials

B. Maruyama, AFRL/RX & Prof Boris Yakobson, Rice Univ
Nucleation and Growth of Carbon Nanotubes



Rice professor's nanotube theory confirmed: Air Force Research Laboratory experiment shows chirality of tube controls speed of growth

PAYOFF

- Develop structures that are more durable & longer-lasting aircraft structures
- Developed carbon nanotube based muscles, which are 30 times stronger than natural muscles
- Created a new form of metal; absorbs all radiation that shines upon it

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RSA Highlights from 2011



- **Materials and Processes Far from Equilibrium**
 - (\$1M/year new initiative led by Sayir, Birkan, Luginsland)
- **Transformational Computing**
 - (\$1.5M/year new initiative led by Smith, Stargel)
- **Hypersonics (Jason's Study)**
 - (Schmisseur invited expert and our newest AIAA Fellow!!!)
- **AFOSR-NSF collaborative agreement & Origami Initiative**
 - (collaborative initiative led by Harrison and Stargel)
 - (RSA's first Basic Research Initiative awarded! Led by Harrison and Stargel)
- **Energy Horizons & AFRL Energy S&T Plan**
 - Year Long Team RSA effort – Les Lee, Birkan, Schmisseur, Berman, Sayir, Harrison and others
- **Materials Genome Initiative**
 - OSTP Initiative to revitalize Material Science and Engineering – RSA experts
Sayir and Harrison

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RSA Changes in 2011



- **Dr. Chiping Li – new PM for Energy Conversion and Combustion Sciences portfolio**
 - 2005-1011-- Aerojet, Chief Engineer Robust Scramjet program and lead for the Hypersonic Analysis Team.
 - 1991-2005 – NRL Scientist
- **Dr. Michael Kendra – new PM for Test and Evaluation portfolio**
 - 2007-2011 – AFRL/RV (Hanscom) Deputy PM Space Object Surveillance Technologies program
 - 1990-2007 – AER/Radex Lead for Infrared and Atmospheric Structure Group
- **Dr. Michael Berman – Sabbatical Leave (Sept-Mar)**
- **Dr. Jeff Owrutsky – PM for Theoretical and Molecular Chemistry**
- **Ms. Laura Cooney – new PM for AFOSR's MURI program**
- **Dr. Kumar Jata – Thermal Sciences PM departed – Leading AFRL/RX Corrosion Study**
- **Lt Kevin Pohl – new masters candidate at AFIT**

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RSA -- Transforming the Future of Aerospace Sciences



- **PROACTIVE** in the basic science research community
- **LEADERS** in the DoD scientific community
- **ADVOCATES** for Air Force S&T
- **MENTORS** for future researchers